The Safety Concern and Redesign of Children's Smartwatch

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Abstract: With the continuous advancement of science and technology, electronic technology has reached new heights, leading to the emergence of increasingly sophisticated electronic products. Among them, children's smartwatches have gained significant popularity. The global children's smartwatch market has experienced substantial growth, with a value of $1,070.97 million in 2022 and an estimated projection of $3,414.81 million by 2028. However, with such a vast market, safety concerns should not be overlooked. These concerns encompass issues such as spontaneous combustion leading to burns, allergic reactions to wearing the watches, high levels of carcinogens in the watch bands, and excessive radiation emissions. To address these challenges, the authors have developed a novel children's watch design, focusing on five key factors: strap material, blue light filtering film, durability, call quality, and positioning functionality. Through an extensive two-month research phase involving offline interviews and online questionnaires, the authors have successfully validated the advantages of their product. The results indicate that 97% of children express willingness to use the product, and 92% of parents are inclined to purchase it for their children, affirming the product's potential for widespread adoption and promotion.

1. Introduction

Governments and other groups are warning that many smartwatches for children can be dangerous with security risk and health concern. For example, many smartwatches for children have built-in GPS trackers, allowing parents to locate their children. Such device, when connected to the internet, can be broken into by unwanted people or kidnappers to collect the information of the children.

During our investigation into the safety issues surrounding smartwatches for children, one of the co-authors discovered a severe allergic reaction experienced by his sister after wearing a children's smartwatch with a polymer band. This reaction resulted in wrist rashes, including redness, swelling, broken skin, and scarring. This incident was not an isolated case, highlighting the presence of multiple safety hazards in children's watches beyond the strap material. As a result, our team embarked on the design of a new children's watch to enhance both the safety standards and user experience for millions of children.

2. Preliminary Research

2.1. Strap

The strap is a generic term for the essential part of a watch that holds the wrist. There are four types of watch bands in the market, namely metal, rubber, leather, and silicone.

The team designed a questionnaire to investigate what kind of problems exist in children's watches. According to the survey, 62% of the children think that the current watch bands on the market are not comfortable to wear, and 27% of the children have encountered a series of problems such as allergies and rashes before.

2.1.1. Metal

Metal bands are divided into precious metal bands and bands made of other metals. One of the

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biggest advantages of metal bands is that they are durable and can be used for a very long time. But the disadvantages of metal straps are also obvious: sweat corrosion and discoloration. Besides, the metal band has direct contact with the skin, it will produce dirt due to the duration of use, habit of watch user, as well as the environment.

2.1.2. Leather

The leather straps are skin-friendly especially in cold autumn and winter season. But the biggest drawback of a leather strap is that it is easy to wear-out and break. In the summer leather strap is more likely to produce odor because of the sweat and water. [1]

2.1.3. Rubber

Rubber straps are generally used in sports watches because one of the biggest advantages of rubber is that it is flexible. However, its disadvantage is that it tends to harden in winter, and the quality of different rubber varies greatly and looks very cheap. [2]

2.1.4. Silicone

As a new material for watch straps, silicone is resistant to high and low temperatures. Compared with natural rubber, it does not harbor bacteria, and its surface tension is very low, so it is not easily deformed by sweat and rain and has strong water resistance. In addition, silicone has good light resistance, chemical stability, wear resistance, and no deformation. But there are also shortcomings in silicon straps: for example, tear resistance of the strap material is low; there might be strap breakage between the silicone strap and the metal ring buckle; furthermore, allergy, rash, and other symptoms are common for silicone watches straps.

2.2. Blue Light Film

Blue light film can reduce the damage of blue light and hence protect children’s eyesight. According to our survey, 78% of parents think their children have obvious vision degradation after using children's watches. The mainstream method of protecting children's vision in the market is to add the eye protection mode, but the eye protection mode still has many drawbacks and causes damage to children's vision. [3]

2.2.1. Disadvantages of eye protection mode

The commonly adopted eye protection techniques to reduce eye strain on smartwatches include adjusting the screen brightness, reducing OLED flickering, switching to night shift, and turning on the dark mode on the display of the watches. Yet long time use of smartwatches will lead to visual cell damage or even vision loss even with the eye protection mode being turned on. Comparative tests have found that the eye protection mode of electronic products can reduce the screen brightness, but the screen brightness is not necessarily the lower the better. The dark screen mode can also cause damage to the eyes. In addition, when the screen brightness is dim, some of the functions such as Alipay and WeChat payment can’t work properly. This might cause inconvenience to many student users. To sum up, the eye protection mode can only prevent short-wave blue light from affecting the eyes, but not long-wave blue light. Adding a layer of advanced blue light film might stop long-wave blue light from damaging children’s vision. [4]

2.3. Continuity

The lower power of the device, the longer the battery life is. The normal battery life of mainstream smartwatches is 2-3 days (the light use lifetime provided by the official websites of Little Genius, Huawei, etc.), and the battery life of children's smart watches is particularly important because children don’t charge their watches as often as adults. According to a questionnaire survey conducted by China Consumer News, 32.98% of consumers said they would pay attention to the battery life when buying children's smartwatches. The complaints and public opinion data also show that the smartwatch has problems such as battery overheat and failure to charge.

2.3.1. User Pain Points

Children need to contact their parents and friends every day and use the watch for entertainment in their leisure time. Children often forget to charge their watches, and parents sometimes forget to charge their children's watches when they are busy, so there are cases when children's watches run out of power during school or lose contact with their parents.

2.3.2. Extension of Battery Life

The are two ways to extend the battery life: 1. turn off the historic track record of the location etc.; 2. disable some of the applications and functions. However, there are some disadvantages in both ways. Although turning off the history track can extend the battery life, the lack of track can only get the invalid position of the last positioning before a long time when the watch is out of power or has no signal, which creates a certain security risk, while disabling some applications and functions will affect the user experience.

2.4. Call Quality

Voice quality, also known as call quality, is related to the entire process of sending, transmitting, and receiving calls from the sender's mouth to the recipient’s ear. According to the questionnaire we distributed, nearly half of the children think the biggest problem in using the smartwatch is that they have difficulties hearing others' speech when they make calls.

User Pain Points: After our telephone interview with the after-sales departments of major watch manufacturers, customer service representatives indicated that most of the watches sent back for repair are due to two reasons: 1. dust or liquid spilled into the microphone head resulting in unclear sound; 2. damaged parts make the smartwatch unusable.

2.5. Positioning

A positioning system is a system that aims to determine spatial location, which facilitates the acquisition of precise latitude, longitude, and altitude to determine the actual location. Using the latitude and longitude of the target obtained from the GPS, together with calls to the map API, the current position and distance of the target can be displayed on the cell phone map. Our team learned from the questionnaire that up to 75% of users think that the positioning of children's watches on the market is not accurate.

Market Research: Most of the branded watches on the market are equipped with nine-fold positioning (GPS, GL.ONASS, base station, Beidou, A-GPS, WIFI, acceleration sensor, indoor positioning, camera assist), which is relatively inexpensive and at the average level of positioning technology in the mass market. However, it was found through online questionnaires and user experience feedback from online searches that the implementation of nine-fold positioning technology fails to effectively address the challenges of precise error control, high latency, and inadequate power supply in children's watches for accurate location tracking. Numerous parents have voiced their complaints regarding the watch's unreliable positioning accuracy, making it challenging to determine the precise geographic location of a child when they are out of immediate reach.

3. Essential Research

3.1. Strap

Based on an objective assessment of the advantages and disadvantages of various materials currently available in the market, a more suitable material for the watch strap is sought. The selected material should possess qualities such as lightweightness, versatility across different scenarios, resistance to sweat during summer and cold weather in winter, as well as enhanced durability and ease of maintenance. In this regard, nylon has been chosen as the preferred material for the strap. In terms of breathability, nylon straps outperform other materials, ensuring a more comfortable wearing experience with reduced wrist discomfort. Another advantage of nylon straps is their lightweight nature, which makes them almost imperceptible when worn. At the same time nylon straps generally

come in a variety of color lines to match and can be co-branded with different IPs to meet the needs of children. And the maintenance of nylon watches is more convenient after the hair needs to use a simply gently cut off the hair on the fire little roast can be, cleaning only need to use a brush like a toothbrush gently brush can be. Finally, the nylon material itself has a certain degree of flame retardancy and can avoid the tragic case of spontaneous combustion like the previous watch.[5,6]

3.2. Blue Light Film

An innovative solution in this context is the addition of a blue light film to the watch design. Unlike conventional screen protectors, this anti-blue light film utilizes a special material known as a nano-layered optical film. This film not only blocks up to 90% of blue light but also maintains up to 95% of light transmission. In short, this means that it effectively blocks blue light while reducing the risk of eye problems caused by overexposure. The Blue Light Film provides more professional protection from blue light compared to other eye protection models for children's watches. The blue light film is generally used to block blue light radiation. It uses blue light blocking technology to absorb and convert blue light, which can effectively block blue light. Blue light is visible light with wavelengths of 400-500 nm in nature. With short wavelengths and strong energy, the retina macula has a certain burning and stimulating effect. If you stare at blue light for a long time may cause retinal damage. For patients who work for long hours and watch too many electronic products such as computers or cell phones, they can use anti-blue light protective film to reduce the damage to the corneal epithelium and macula in the fundus, to protect children's eyesight. [7,8]

3.3. Continuity

In this regard, an alternative approach is proposed to address this issue. Rather than focusing solely on extending the watch's battery life, the suggested approach emphasizes the importance of daily charging for parents. By ensuring regular charging, the functionality of the watch can be maintained, thereby enhancing the overall user experience for children on the following day. At present, the watch already sends a notification to the phone via the app to remind charging, but according to our questionnaire, about 80% of the parents think that the notification is not in place and has no practical effect. At the same time, we designed the AI phone function to remind parents to charge the watch in time when the battery level is less than 20%, which can be turned off and on according to parents' needs to ensure that the battery level of the child's watch is always sufficient.

3.4. Call Quality

The plan is to install microphone waterproof sound-transparent film on the watch case microphone (microphone waterproof breathable film is actually a new type of polymer waterproof material. It has a special fiber-like microporous structure with high mechanical properties and small pore size, and has the characteristics of being waterproof and breathable). First of all, it can be very effective in isolating water, salt, or other corrosive liquids (such as carbonated drinks, coffee, etc.) can play a protective role. In addition, the windproof and energy-saving properties of the waterproof and breathable membrane have received relatively high-frequency attention. It can withstand external wind attacks, maintain good flexibility at low temperatures, and is lightweight, among other characteristics.

To sum up, the waterproof breathable film installed on the microphone head proposed by our team can well hit the pain point that users can't hear the sound clearly during the call, and the characteristics of waterproof, high lubrication, non-adhesive and non-injurious can effectively prevent the phone watch from having inaudible sound due to dust or liquid splashing in the microphone head.

3.5. Positioning

The goal is to create a watch that will satisfy and reassure customers through the positioning function. The proposed eleven-fold positioning system, incorporating air pressure-assisted floor positioning and track projection-assisted positioning, offers an enhanced solution compared to the conventional nine-fold positioning system found in phone watches. This advanced watch not only encompasses all the functions of a nine-fold positioning system, but also ensures precise child

location tracking, even in remote areas with minimal signal coverage. Parents can access real-time information regarding their child's location, even in such challenging environments. Additionally, to further improve positioning accuracy, a combination of offline positioning techniques has been implemented. Even if the watch is low on power or has a bad signal, parents can check the exact location in real-time through the app. Our advantage is that no matter where the child is wearing the watch with this positioning configuration, the parents can quickly and accurately check the real-time location through the positioning system, thus ensuring the safety of the child.

4. Verification Results

4.1. Strap

Through online questionnaires and offline experience with children, many parents aware of the limitations of the current straps on the market. The survey and parents' feedback shows that the straps we designed were only suitable for some watch types. A range of different styles and sizes of straps were quickly produced to accommodate the preferences of children. These variations were designed to meet the specific requirements of individual children. After a month of use, based on the feedback received from return questionnaires, it was found that 88% of the children considered the nylon strap to be more comfortable compared to other options.

4.2. Blue Light Film

At present, through offline visits and selected questionnaires, many parents are aware of the unreliability of the eye protection mode and are very willing to try our new product blue film. However, as the survey progressed and based on the feedback received from parents, it was identified that the Blue Light Film product was only compatible with certain models of children's watches, thereby limiting its usability for some children. In response, an immediate course of action was taken to address this issue. Different sizes were promptly developed, and a wider range of models was added to ensure compatibility across a broader spectrum of children's watches. These revised versions were then distributed to children for their use.

After two months of use, the return questionnaire showed that 85% of the children thought the blue film was better than the eye protection model because there would be no color difference. And parents also feel good about the blue film, 96% of parents are very willing to use the blue film for a long time in the future because there is already a trend of 38% of children showing a slowdown in the increase of myopia.

4.3. Continuity

At present, many parents approved our proposed notification method through our offline visits and selected questionnaires, and three groups of parents and children who often forget to charge their watches participated in our experiment. Given the temporary unavailability of AI phone calls, a method was implemented to verify the reasonableness of the envisioned solution. Parents were contacted directly at 9:00 pm each day to provide reminders about charging their children's watches. This approach served as an objective means to assess the effectiveness of the proposed solution.

After a week of telephone reminders, the children reported that their watches never had a low watch charge every night this week, and they were able to use their watches freely every day. However, some parents of the children reflected that the AI calls caused some interference in their lives, and they also suggested that some parents might turn off this function. Based on the observations made, it was determined that improvements were necessary for the original solution. To address the issue of parents repeatedly forgetting to charge the watch, a revised approach was devised. Parents who have disabled the AI phone function will be identified, and they will be reminded to consider enabling this function. Additionally, the importance of watch battery life will be emphasized to ensure the uninterrupted functionality of their children's watches. This enhancement aims to improve the overall user experience and ensure the reliable usage of the watches.

4.4. Call Quality

The plan is using a waterproof and breathable membrane to simulate a call, [9] prepared two microphones, one with a waterproof and breathable membrane around it and the other without any protection, and sprayed water and sprinkled cookie crumbs on both microphones while they were playing the same audio. The results showed that the microphone with waterproof and breathable film protection produced a clearer sound than the unprotected microphone, and the microphone was less stained and easier to clean. Then, nearly 27 children were then invited to listen and assess the quality of sound transmission. 85.19% of children think that microphones with waterproof and breathable membrane protection release clearer sound. Through offline visits and the optional questionnaire, it was observed that many parents acknowledged the influence of dust on the microphone's lifespan and call quality. They expressed their approval of the approach to enhance call quality and indicated a willingness to recommend it to others in their social circle.

4.5. Positioning

Based on the analysis of offline interviews and online questionnaires, data was collected and revealed that 86% of the users express support for upgrading the accuracy of the nine-fold positioning system. [10,11] Additionally, 89% of the users agree with and support our design of the offline positioning solution. Furthermore, they express a willingness to actively contribute to the promotion of this positioning system. These findings indicate that the design solution is substantiated and effectively addresses the concerns of the users, instilling confidence in parents' purchasing decisions and ensuring a satisfactory experience for children.

5. Conclusion

At the beginning of the project, it was discovered that mainstream children's watches on the market suffer from various drawbacks, significantly hindering the user experience for children. The aim is to develop a new watch that can address these limitations and enhance the overall user experience for children. Currently, the researchers have designed prototypes for the watchband and incorporated a blue film. Upon completion of this project, a notable improvement in the quality of children's watches is expected, representing a significant leap compared to the existing popular products available in the market.

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